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## **12-hour ultra-marathons - Increasing worldwide participation and dominance of Europeans**

Sehovic, Edis ; Knechtle, Beat ; Rüst, Christoph Alexander ; Rosemann, Thomas

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# 12-hour ultra-marathons - Increasing worldwide participation and dominance of Europeans

EDIS SEHOVIC<sup>1</sup>, BEAT KNECHTLE<sup>2</sup> , CHRISTOPH ALEXANDER RÜST<sup>1</sup>, THOMAS ROSEMAN<sup>1</sup>


<sup>1</sup> Institute of General Practice and for Health Services Research, University of Zurich, Zurich, Switzerland

<sup>2</sup> Gesundheitszentrum St. Gallen, St. Gallen, Switzerland

## ABSTRACT

Sehovic, E., Knechtle, B., Rüst, C.A. & Rosemann, T. (2013). 12-hour ultra-marathons - Increasing worldwide participation and dominance of Europeans. *J. Hum. Sport Exerc.*, 8(4), pp.932-953. Ultra-marathon running is of increasing popularity. Participation and performance trends in ultra-marathons have been previously investigated for 100 mile runs, multi-stage ultra-marathons, triathlons and ultra-triathlons, but not for 12-hour runs. We examined participation and performance trends in 12-hour runs held all over the world. Gender, nationality and age in runners competing in 12-hour runs worldwide from 1981 to 2010 were investigated. The annual number of participants in 12-hour runs increased significantly over time for athletes originating from Africa, Asia, Europe, North America and Oceania ( $P < 0.05$ ). Most of the runners participated in races taking place in the USA and also the most runners originated from the USA, which was followed alternately by Germany and France. Top ten European runners achieved the longest running distances with an average of  $134.7 \pm 1.9$  km for women and  $155.8 \pm 2.5$  km for men, facing the top three nations Russia, Germany and Japan with  $130.7 \pm 2.6$  km and  $154.1 \pm 3.4$  km,  $131.8 \pm 3.5$  km and  $146.8 \pm 4.1$  km,  $132.1 \pm 4.3$  km and  $144.9 \pm 1.3$  km for the top ten women and men, respectively. To summarize, participation in 12-hour runs increased in the last 30 years. Europe was the continent with the highest annual number of participants and where the most runners came from. European top ten runners achieved the best performances. Future studies about 12-hour runs need to investigate up to what extent participation and performance trends depend on aspects like age, training, anthropometry, nutrition, experience, and weather. **Key words:** ULTRA-ENDURANCE, PERFORMANCE, RUNNING.

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 **Corresponding author.** Facharzt FMH für Allgemeinmedizin, Gesundheitszentrum St. Gallen, Vadianstrasse 26, 9001 St. Gallen, Switzerland  
E-mail: beat.knechtle@hispeed.ch  
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## INTRODUCTION

Ultra-marathon running is of increasing popularity (Hoffman, 2010; Hoffman & Wegelin, 2009; Knechtle et al., 2011a, 2012a; Lepers, 2008, 2010; Skenderi et al., 2006). Participation in endurance sports showed a trend to longer events (Zaryski & Smith, 2005; Knechtle et al., 2011a), and new distances such as ultra-triathlons (Knechtle et al., 2011a, 2011b; Lepers et al., 2011; Sigg et al., 2012), which equate to a multiple of an Ironman triathlon, have been created to increase the availability for runners who are looking for yet harder challenges.

Since ultra-marathon is an ultra-endurance competition, defined as an endurance performance exceeding six hours in duration (Zaryski & Smith, 2005), numerous events are fulfilling this definition, classified either in time- or distance-limited ultra-marathons. For running, the most common distance- and time-limitations are 50 km and 100 km or 161 km, and 6 h, 12 h, 24 h, 48 h, and 72 h, respectively ([www.ultramarathonrunning.com](http://www.ultramarathonrunning.com)). These races are held generally outside mainly on loops of less than 10,000 m. In line with this, a 12-hour run is either held on track or field, typically on loops shorter than 5,000 m. For example, the time limited '12-Stunden-Lauf' held in Basel, Switzerland, is run on a circuit of 1,141.86 m (<http://ch.srichinmoyraces.org>) contrary to the distance-limited '100 km Lauf Biel' held in Biel, Switzerland, (<http://www.100km.ch>), which is held on a large single loop.

There are several studies about ultra-endurance competition, investigating participation and performance trends for ultra-endurance athletes such as ultra-marathoners (Hoffman & Wegelin, 2009; Hoffman, 2010), Ironman triathletes (Lepers, 2008) and ultra-triathletes competing in triathlon distances longer than the Ironman distance (Knechtle et al., 2011a, 2011b). However, no study investigated participation and performance trends in 12-hour ultra-marathoners. More specifically, to date most of the studies investigated a particular running competition (Skenderi et al., 2006), a competition series (Brannen & Milroy, 2004; Hoffman, 2010; Hoffman et al., 2010; Hoffman & Wegelin, 2009), but no study collected and analyzed data of a whole competition series worldwide. Since the 12-hour run is a form of ultra-marathon or an ultra-endurance sport event, the series of studies about ultra-endurance competition features a gap.

Previous studies investigating endurance and ultra-endurance competitions showed the common finding of an increase of participants (Hoffman, 2010; Jeffery, 2012; Jokl et al., 2004; Knechtle, 2010, 2011a; Lepers et al., 2011). An increasing participation was reported for the 'The New York City Marathon' (Jokl et al., 2004; Lepers & Cattagni, 2012), races held over the Double Iron ultra-triathlon distance (Knechtle, 2010) and the Triple Iron ultra-triathlon distance (Jeffery, 2012; Knechtle, 2010, 2011a) and for 161-km ultra-marathons held in the USA (Hoffman, 2010). Additionally, the latter study showed that the increase in participation amongst others was caused by a growth in participation among women from virtually none in the late 1970s to nearly 20% since 2004. Similar was reported for marathons, in particular, participation of master runners increased to a greater extent for women compared to men (Lepers & Cattagni, 2012). However, to avoid false conclusions when comparing 12-hour runs with ultra-endurance events like multiple-day 'pedestrian' races in the USA, it has to be considered that these races in the USA date back to the 1800s (Brannen & Milroy, 2004; Hoffman & Wegelin, 2009; Milroy, 2004; Noakes, 2003), whereas the first 12-hour run took place at a much later date in Brühl (GER) in 1981 ([www.12-stunden-lauf.de](http://www.12-stunden-lauf.de)). In this comparison the 12-hour run appears relatively young and therefore it could be possible that it has not established in full extent yet. For this reason a comparison to younger sport events might be indicated like the Double Iron ultra-triathlon (Knechtle et al., 2011a) or the Triple Iron ultra-triathlon (Jeffery et al., 2012; Knechtle et al., 2011a) which were first held in 1985 and 1988, respectively. For Double Iron ultra-triathlon, the number of female starters slightly increased and accounted for 10% from 1999-2009 (Knechtle et al.,

2011a) and for Triple Iron ultra-triathlon participation of men increased over the 24-year period while the participation of women remained stable at ~8% of the total field (Jeffery et al., 2012; Knechtle et al., 2011a).

Concerning participation in distance running events such as marathon Burfoot (2007) found that since the early 1980s, it has advanced with hundreds of marathons worldwide. In view of the fact that the increasing popularity exhibits a worldwide character, it puts us in position to compare performance trends according to nationality. To date, literature about predestining factors of specific ethnic groups exists. Larsen (2003) found Kenyan dominance in distance running. Scott et al. (2003) examined elite Ethiopian endurance runners and showed an advantage of demographic characteristics. Lucia et al. (2006) examined physiological characteristics of the best Eritrean runners and found exceptional running economy. Summing up, for distance running in general East African runners were dominating.

For the present study we focused on findings regarding Triple Iron ultra-triathlon (Jeffery, 2012) and Double Iron ultra-triathlon (Rüst et al., 2012; Sigg et al., 2012), showing a dominance of European athletes in both participation and performance. The purpose of the present study was to amend the series of studies regarding ultra-endurance events. Therefore we examined participation and performance trends in 12-hour runs all around the world since the inception in 1981 until 2010. The aims of the present study were (i) to investigate participation trends in 12-hour runs, (ii) where these runs are held and which nationalities are represented, (iii) the performance referring to nationality, and (iv) the difference of participation among women and men. Due to existing literature regarding marathons, ultra-marathons, triathlons and ultra-triathlons, we hypothesized (i) an increase in the number of participants and 12-hour runs, (ii) most of the races would be organized in Europe and coherent to this most participants would come from Europe. Further, we hypothesized that (iii) European runners would show off the best performances and (iv) a stable participation of women.

## MATERIAL AND METHODS

All runners who ever participated in a 12-hour run worldwide between 1981 and 2010 were analyzed regarding participation trends in genders and nationality, and the association between sex and nationality with performance. The data set from this study was obtained from <http://statistik.d-u-v.org/>. This study was approved by the Institutional Review Board of St. Gallen, Switzerland, with waiver of the requirement for informed consent given that the study involved the analysis of publicly available data.

### *Data analysis*

In total data were available from 14'641 runners, including 3'149 women, 11'490 men and two without information about sex. These two runners were excluded from analysis. Additionally, 45 men and 18 women had to be excluded because no information about the year of participation was given. From 329 women and 870 men no information about age was given and thus these runners were excluded from analyses concerning aspects of age. The remaining 13,377 runners were all included in the further analyzes. First of all, countries where races took place and their locations around the world were determined. Then, the number of participants of races per continent as well as per origin continent of the runners was analyzed first in total and additionally the development over time. The travelling manner of runners, who participated in races taking place outside their origin continent, was investigated. Participation in races taking place in countries, that could welcome at least 100 women and men each, was determined. These countries were the United States of America (USA), France (FRA), Germany (GER), Russia (RUS), Austria (AUT), Switzerland (SUI), Canada (CAN), Australia (AUS), Hungary (HUN) and Republic of South

Africa (RSA). The same analysis was performed for nations wherefrom at least 100 women and men each originated. These countries were the United States of America (USA), Germany (GER), France (FRA), Russia (RUS), Austria (AUT), Canada (CAN), Hungary (HUN), Republic of South Africa (RSA) and Japan (JPN). To investigate performance regarding geographical origin we determined and analyzed the overall top ten women and men per continent as well as per country.

### *Statistical analysis*

In order to increase the reliability of data analyses, each set of data was tested for normal distribution as well as for homogeneity of variances in advance of statistical analyses. Normal distribution was tested using a D'Agostino and Pearson omnibus normality test and homogeneity of variances was tested using a Levene's test in case of two groups and with a Bartlett's test in case of more than two groups. To find significant changes in the development of a variable across years, linear regression was used. Statistical analyses were performed with IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA) and GraphPad Prism (Version 5, GraphPad Software, La Jolla, CA, USA). Significance was accepted at  $P < 0.05$  (two-sided for t-tests). Data in the text are given as mean  $\pm$  standard deviation (SD).

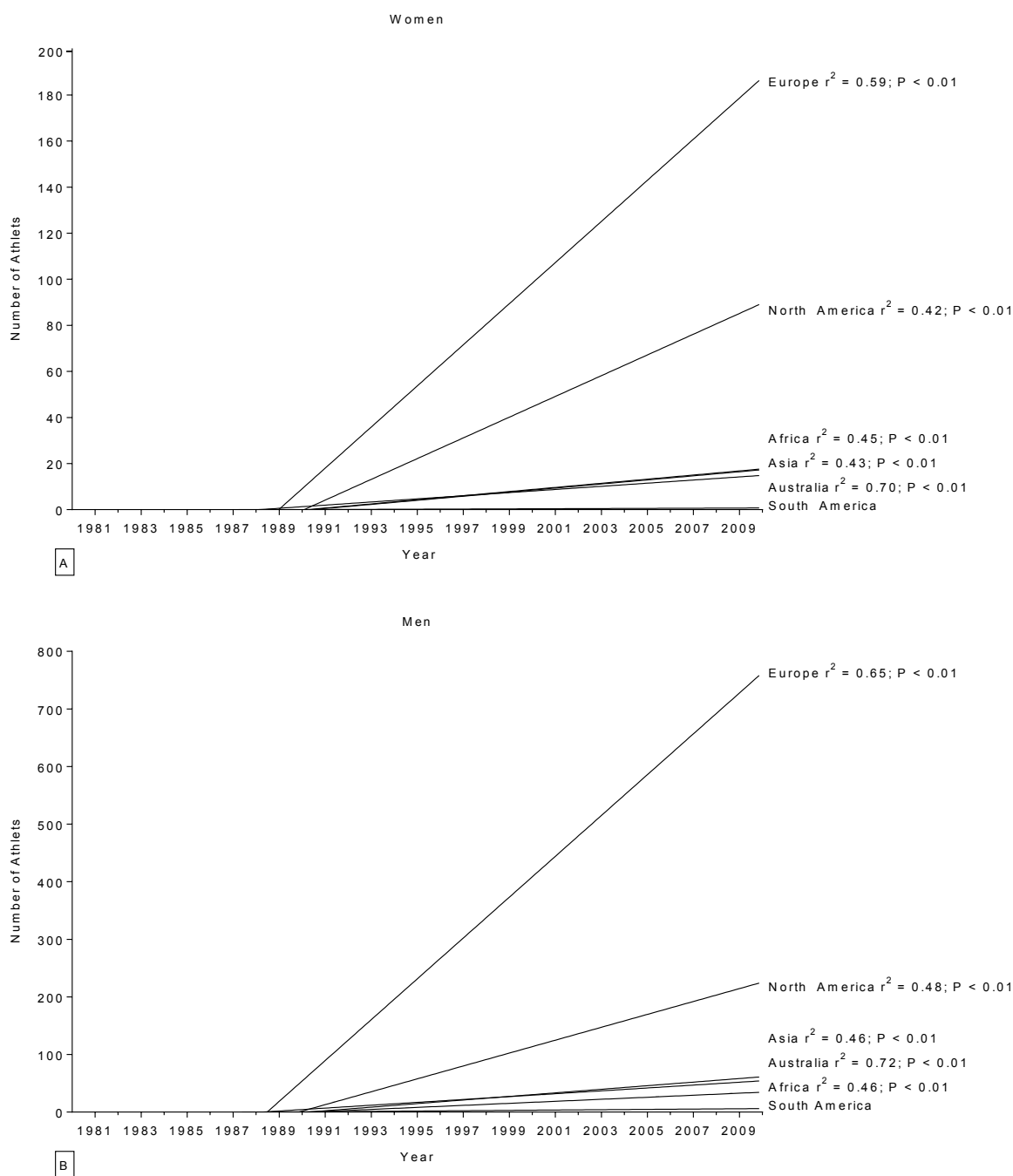
## RESULTS

In total complete data were available from 13,377 runners, whereof 10,607 were men and 2,770 women.

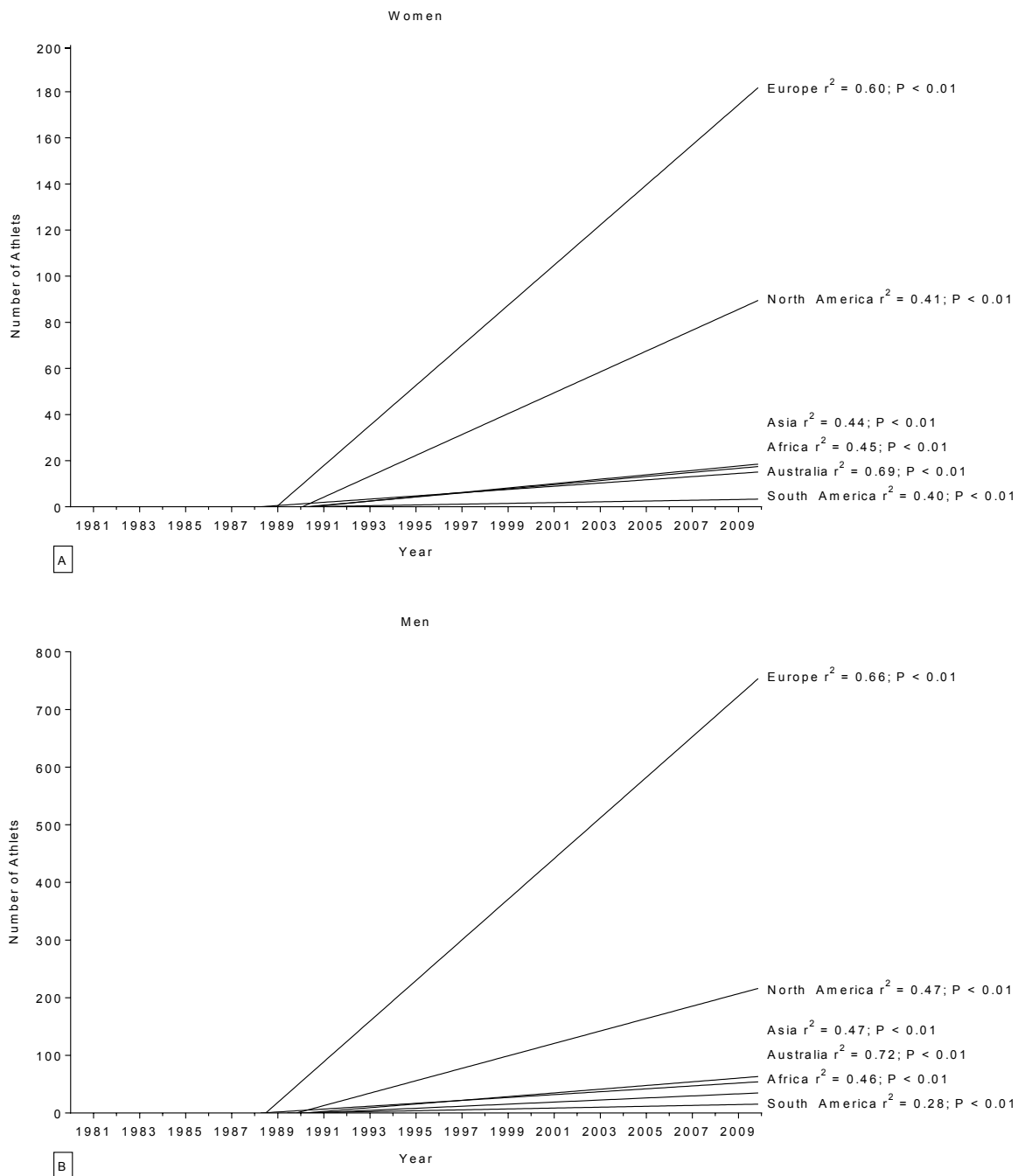
### *Number of races and participation*

The 12-hour runners originated from 57 countries all over the world. They participated in 198 different races which were carried out in 35 different countries on all 6 continents. The number of countries in which at least one 12-hour run was organized increased over the study period is shown in Table 2. In the first ten years almost all races took place in Europe, compared to North America, where the first races have been arranged in the early 90's. According to the increased number of races the development of the annual number of women and men, participating in a 12-hour run, also increased. Concretely, with the sole exception of South America all continents (Figure 1) ( $r^2=0.42-0.72$ ;  $P < 0.01$ ) and all origin continents (Figure 2) ( $r^2=0.28-0.72$ ;  $P < 0.01$ ) showed a significant increase in the annual number of participants between 1981 and 2010. In races taking place in South America (Figure 1), the number of women ( $r^2=0.05$ ;  $P=0.253$ ) and men ( $r^2=0.05$ ;  $P=0.249$ ) did not increase.

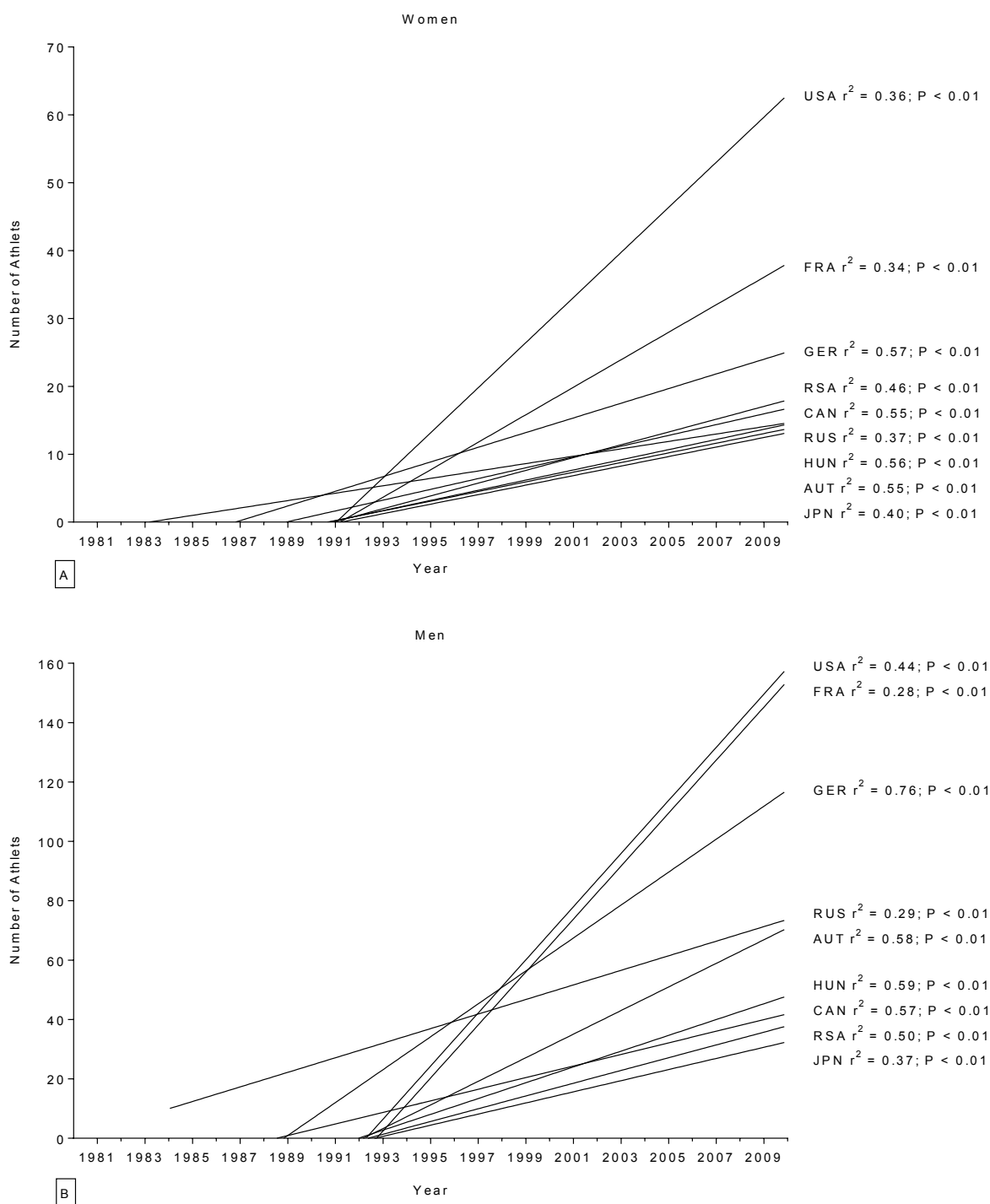
Analogue to participation concerning continent all countries, except of Switzerland, showed a significant increase. Concretely, countries which provided (Figure 3;  $r^2=0.28-0.76$ ;  $P < 0.01$ ) and in which at least 100 women and men each participated (Figure 4;  $r^2=0.25-0.73$ ;  $P < 0.01$ ) showed a significant increase in the annual number of participants for both genders. The USA provided most of the runners with  $20.3 \pm 45.3$  women and  $50.1 \pm 101.6$  men, respectively (Figure 3). The USA has also the largest number of participants, namely  $23.3 \pm 51.9$  women and  $59.3 \pm 123.3$  men (Figure 4). Concerning the number of participants the USA are directly followed by Germany with  $16.2 \pm 44.5$  women and  $53 \pm 158.5$  men, and France with  $9.3 \pm 10.2$  women and  $45.6 \pm 47.1$  men, respectively. Germany and France provided  $11.2 \pm 11.8$  women and  $50.2 \pm 48.2$  men, and  $12.1 \pm 2.86$  women and  $46 \pm 12.75$  men, respectively.



**Figure 1.** Annual number of female (Panel A) and male (Panel B) runners participating in a 12-hour run per continent between 1981 and 2010

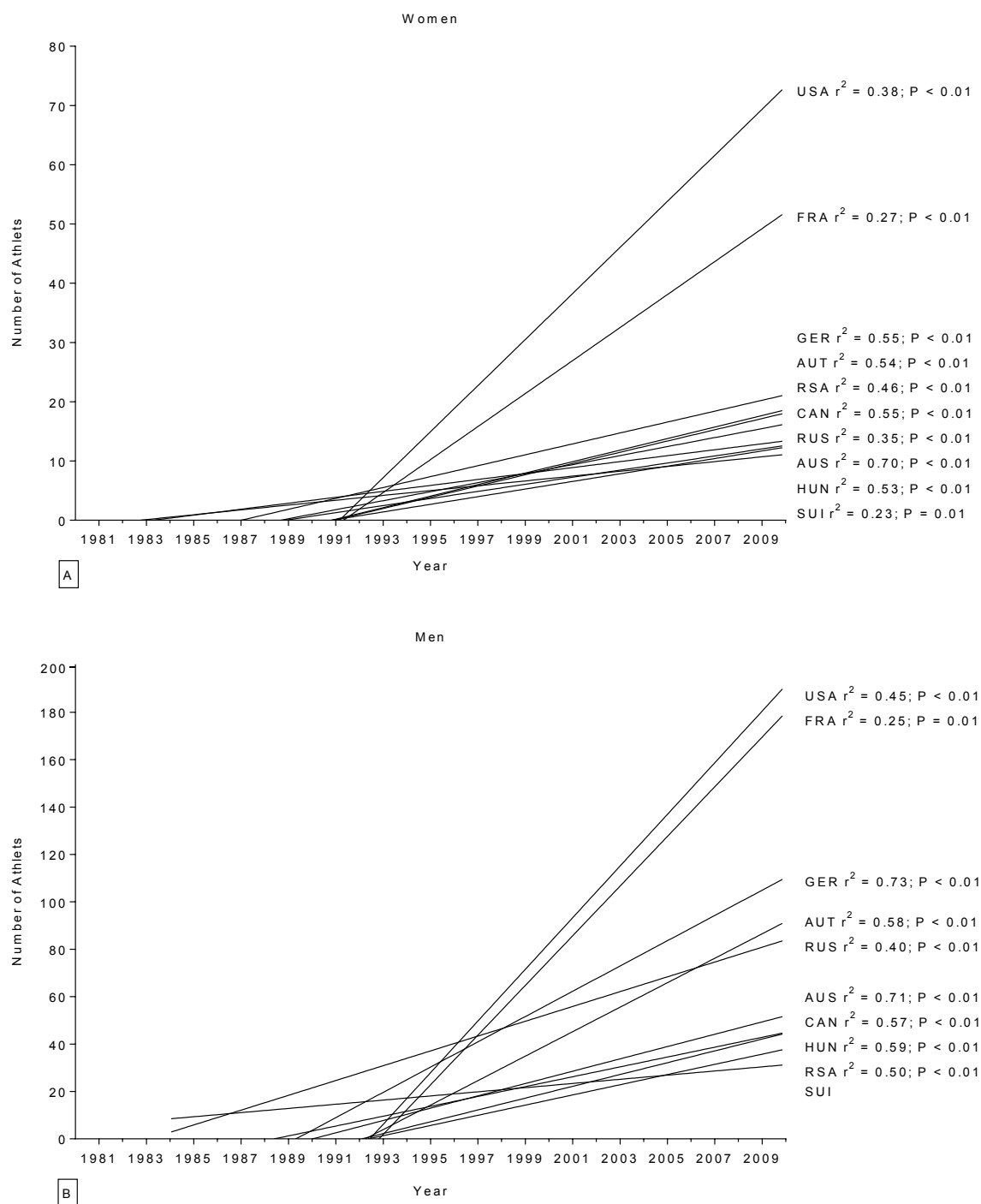


**Figure 2.** The annual number of female (Panel A) and male (Panel B) runners originating from a specific continent and participated in a 12-hour run between 1981 and 2010



**Figure 3.** The annual number of female (Panel A) and male (Panel B) runners per country





**Figure 4.** The annual number of female (Panel A) and male (Panel B) runners participating in runs taking place in countries between 1981 and 2010

Most of the races took place in Europe, with a total of 372 races and 9,668 participants, followed by North America with 121 races and 2,832 participants, respectively (Table 2). Accordingly, Europe had the highest participation (Figure 1) and origin (Figure 2) rate with  $65.8 \pm 98.6$  women and  $279.5 \pm 371.4$  men, and with  $64.4 \pm 94.9$  women and  $277.7 \pm 367.6$  men, respectively. Europe was followed by North America with a participation rate of  $28.3 \pm 58.7$  women and  $72.9 \pm 136.9$  men, and the rate of  $28.4 \pm 59.8$  for women and  $70.7 \pm 132.4$  for men as origin continent, respectively. In general, native runners represented the largest part of participants (Figure 5). Regarding the origin or the travelling manners of runners, respectively, the largest number of runners who travelled to another continent to participate in a race, came from South America and Asia, namely 98 and 68 runners, respectively. In contrast to that the smallest number, namely 4, came from Africa. The continent that welcomed the largest relative part of participants from another continent was Asia followed by North America, with 4.1% and 3.7%, respectively.

#### *Performance in dependency of geographical origin*

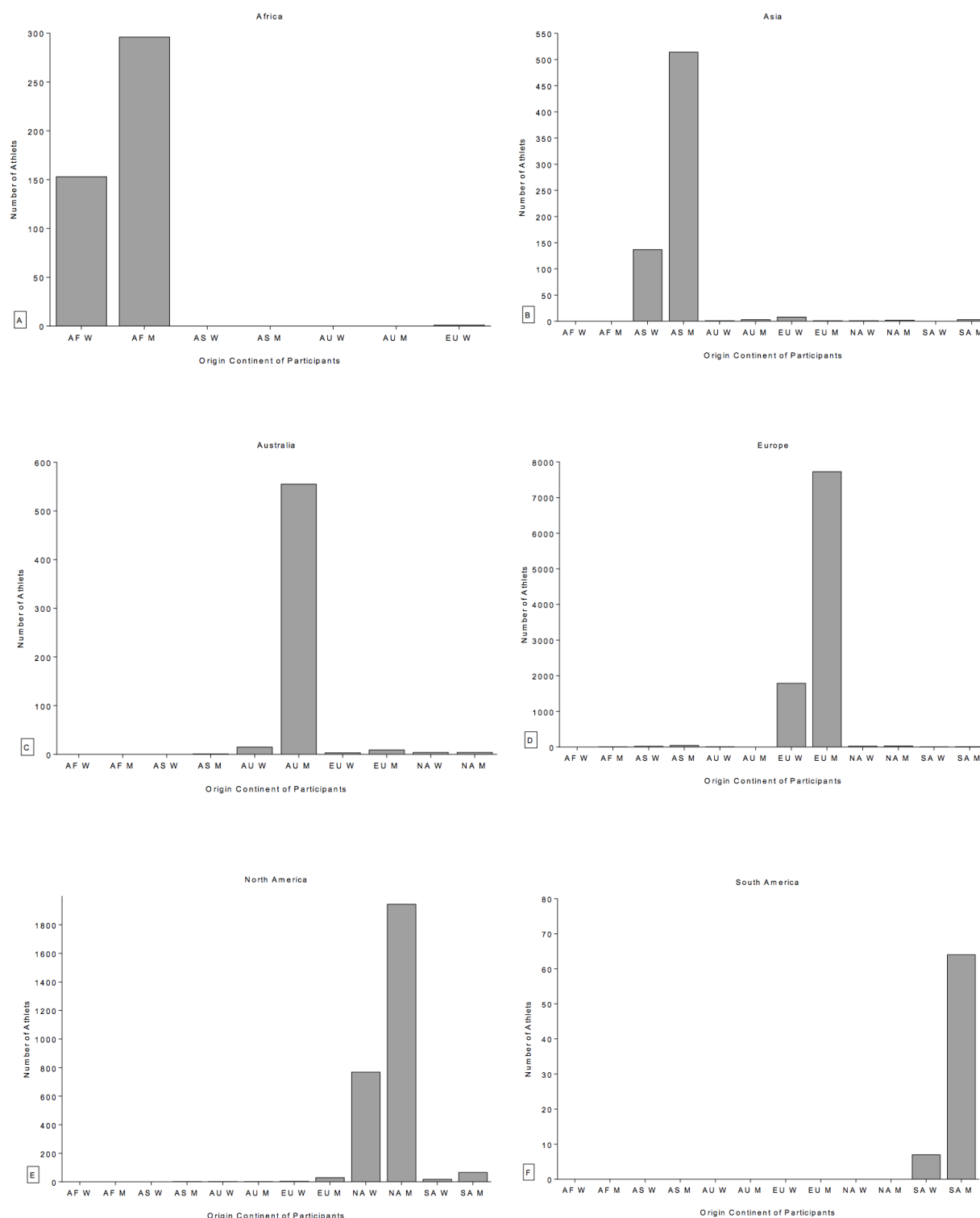
The longest running distances were achieved by top ten European runners with  $134.7 \pm 1.9$  km for women and  $155.8 \pm 2.5$  km for men, followed by top ten Asian runners with  $132.1 \pm 4.3$  km for women and  $144.9 \pm 1.3$  km for men, and top ten North American athletes with  $127.0 \pm 6.9$  km for women and  $141.7 \pm 8.3$  km for men (Figure 7). Regarding the country of origin of runners, the top three women and men came from Germany, Japan and Russia (Figure 8). Only the sequence of the women and men ranking differed. Japanese women were on pole position with  $132.1 \pm 4.3$  km and on the other hand Russian men, who pulled more distinctly with  $154.1 \pm 3.4$  km. German women came second place with  $131.8 \pm 3.5$  km being followed by Russia with  $130.7 \pm 2.6$  km. The male second and third position was represented by Germany and Japan with  $146.8 \pm 4.1$  km and  $144.9 \pm 1.3$  km, respectively.

#### *Correlation between income, population and participation*

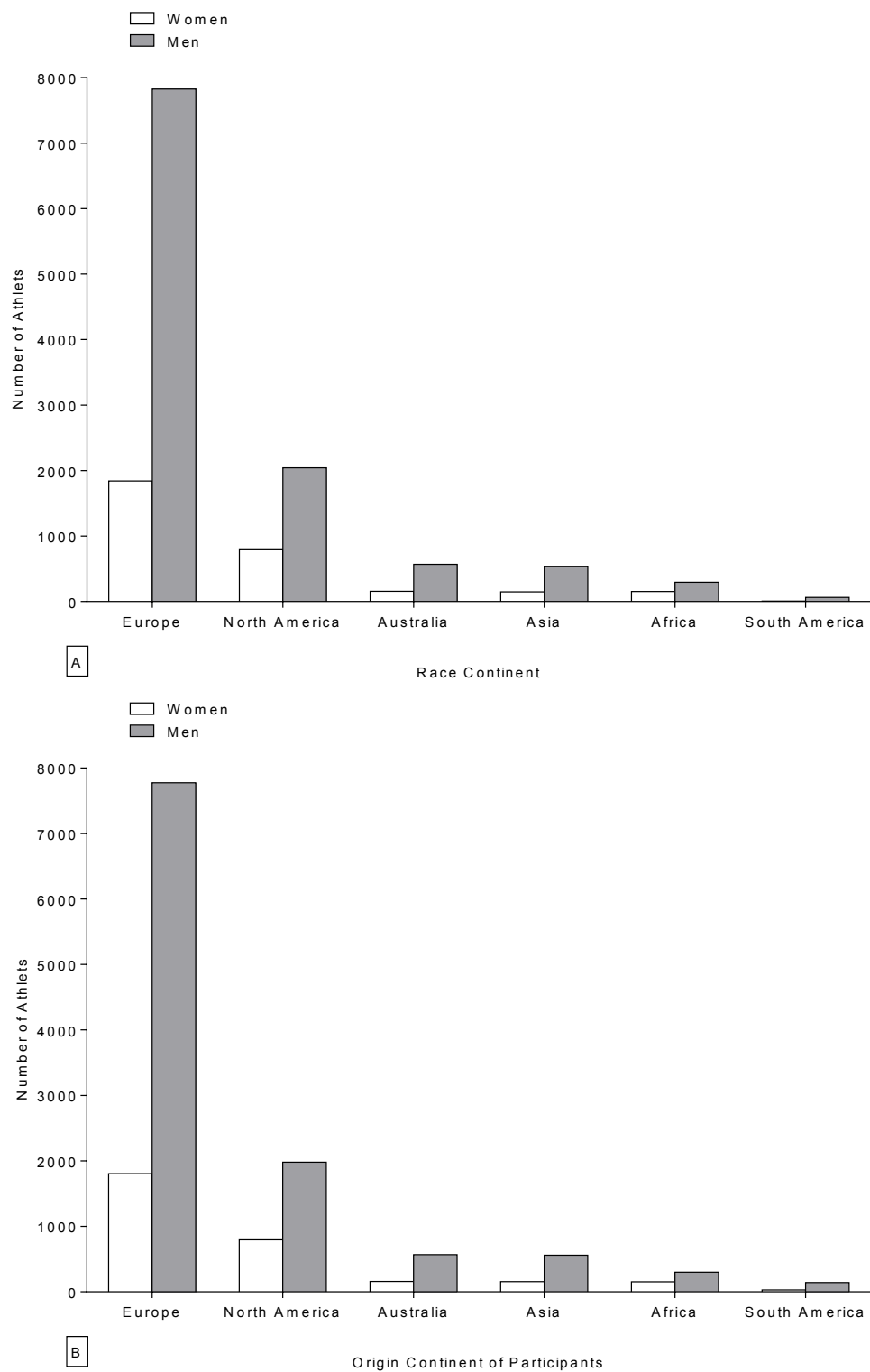
Population increased significantly for all countries in the comparison of the year 1981 to 2010 except of Hungary and Russia (Table 1). Participation increased significantly for all countries. Income per person increased significantly for all countries but Russia, whereof no data was available for 1981. The correlation between participants and population, and participants and income per person, respectively, was significant for all countries but Russia, whereof no analysis was possible.

#### *Differences in participation between women and men*

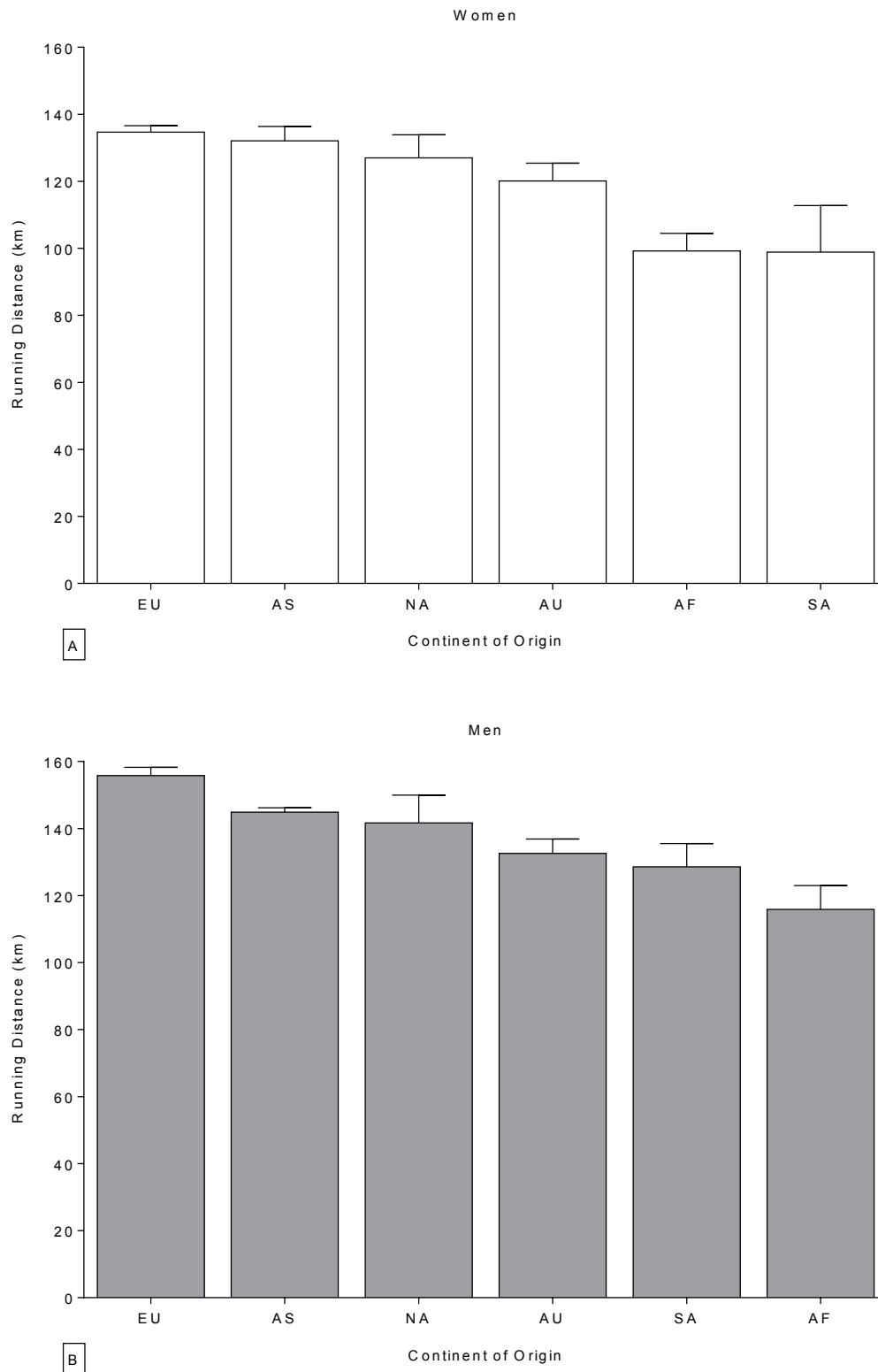
The number of participants regarding continent (Figure 6) in descending order was 8,951 for Europe followed by 2,621 for North America, 593 for Australia, 484 for Asia, 405 for Africa and at last 50 for South America. Regarding gender, the percentages were almost identical in both cases, i.e. as race continent and as origin continent of participants, with the sole exception of South America, and in either case to the benefit of men. The overall (13,104) average percentage of women (2,744) and men (10,360), who participated in 12-hour runs from the inception in 1981 to 2010 were ~21% and ~79%, respectively.



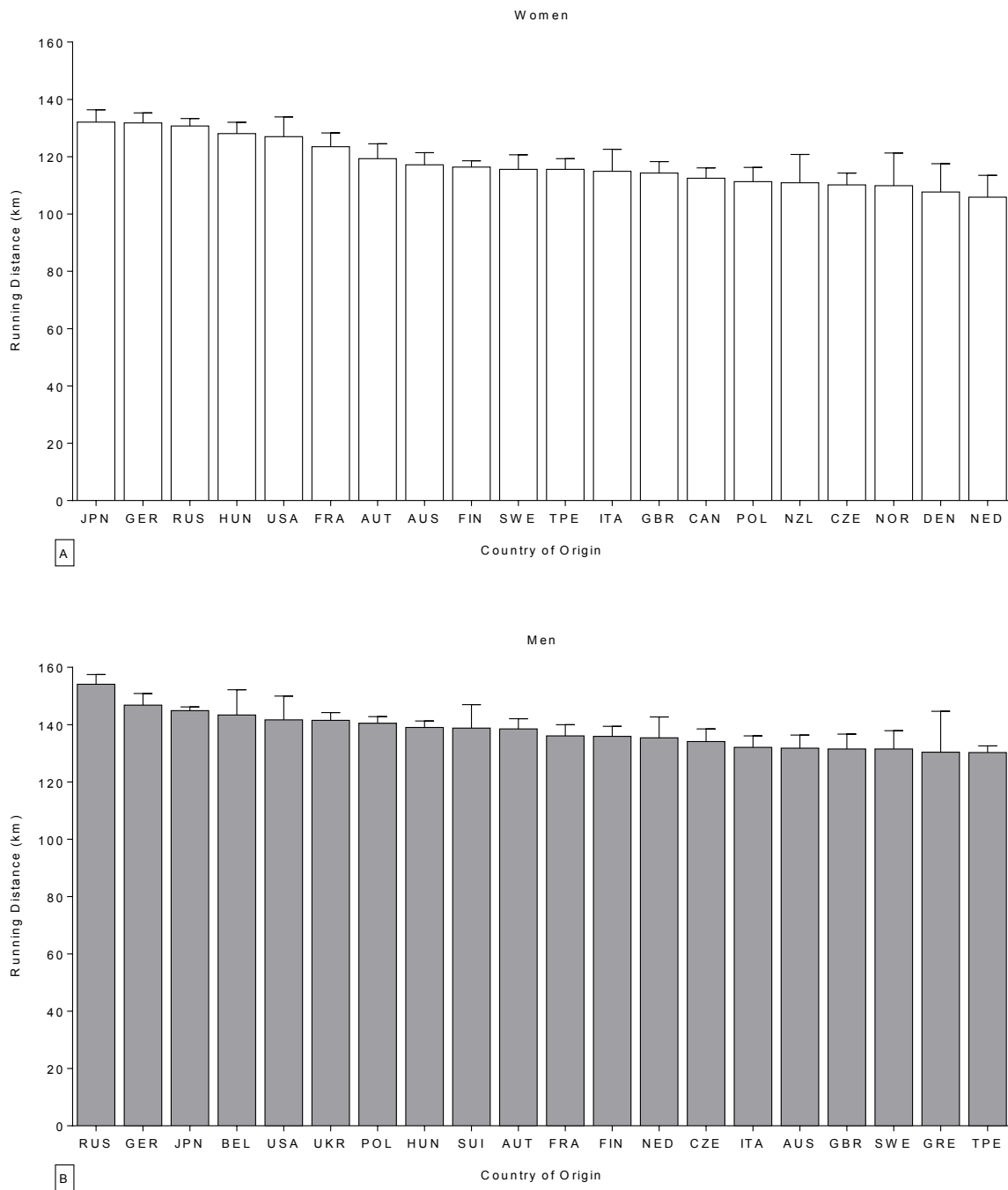
**Figure 5.** Number of women and men originating from a different continent and started in races in Africa (Panel A), Asia (Panel B), Australia (Panel C), Europe (Panel D), North America (Panel E) and South America (Panel F). The race participants are encoded as follows: AF=Africa, AS=Asia, AU=Australia, EU=Europe, NA=North America, SA=South America; F=Women, M=Men



**Figure 6.** Total number of women and men participating in a 12-hour run on a specific continent (Panel A) and in the total number of runners that came from a specific continent (Panel B)



**Figure 7.** Running distance of the top ten women (Panel A) and top ten men (Panel B) per continent of origin. Continents are arranged by running time



**Figure 8.** Running distance of the top ten women (Panel A) and top ten men (Panel B) per. Nations are arranged by running time and the frame indicates only the 20 fastest nations

**Table 1.** Correlation between income per person, population and participation for countries that could welcome at least 100 women and men each

	Participants				Population (in 1000)				Income per Person				Participants / Population		Participants / Income	
	1981	2010	$r^2$	$P$	1981	2010	$r^2$	$P$	1981	2010	$r^2$	$P$	$r$	$P$	$r$	$P$
AUS	0	80	0.70	<0.0001	14927	22300	0.99	<0.0001	10000	36910	0.98	<0.0001	0.89	<0.01	0.89	<0.01
AUT	0	171	0.52	<0.0001	7569	8390	0.97	<0.0001	11340	39800	0.99	<0.0001	0.74	<0.01	0.74	<0.01
CAN	0	102	0.61	<0.0001	24900	34126	1.00	<0.0001	11920	38370	0.97	<0.0001	0.81	<0.01	0.81	<0.01
FRA	0	1004	0.23	0.0071	55440	65076	0.99	<0.0001	10470	34760	0.99	<0.0001	0.65	<0.01	0.65	<0.01
GER	1	203	0.72	<0.0001	78408	81777	0.79	<0.0001	10880	38100	0.97	<0.0001	0.84	<0.01	0.94	<0.01
HUN	0	86	0.54	<0.0001	10712	10000	0.97	<0.0001	5550	19550	0.89	<0.0001	0.74	<0.01	0.74	<0.01
RSA	0	86	0.46	<0.0001	28255	49991	1.00	<0.0001	4500	10330	0.88	<0.0001	0.70	<0.01	0.70	<0.01
RUS	0	27	0.51	<0.0001	139941	141920	0.01	0.5468	0	19210	0.80	<0.0001	0.02	0.92	0.47	0.01
SUI	0	52	0.23	0.0077	6354	7826	0.99	<0.0001	16220	49960	0.97	<0.0001	0.65	<0.01	0.65	<0.01
USA	0	764	0.39	0.0002	229466	309350	1.00	<0.0001	13510	47310	0.99	<0.0001	0.81	<0.01	0.81	<0.01

**Table 2.** Number of 12-hour runs taking place in the referring country

Continent	Country	1981	1983	1984	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	
AF	RSA																							75	31	77	93	88	86	450	
AS	JPN																						4	11	1	4	48	61	133	262	
	TPE																					2	72	6		6	46	54	56	242	
	KOR																							4			11	12		27	
	KAZ																												13	13	
AU	AUS										3	3	2				3	5	24	31	35	5	47	58	82	85	34	53	8	478	
	NZL																2	5	5	7	9	15	7	6	8		6	7	9	86	
EU	GER	1		1	2	1	1	2	7	3	63	25	6	9	17	17	1	14	4	119	96	86	122	92	128	92	16	121	23	1069	
	RUS											29	27	75	25	143	111	11	76	16	65	15	7	67	59	76	93	79	27	1001	
	AUT								1													11	31	1	126	12	159	169	171	681	
	FRA										8				18									123	1	135	187	172	14	658	
	SUI							34	29	26	2		26	26	2	136			21		32	3	24	31	25	3	49	58	52	579	
	HUN																						38	54	65	8	69	74	86	394	
	POL																	15	19	22	28	27	3	36	39	47	55		67	358	
	ITA																		54	43				74	41	4	52	38	26	332	
	NED													56	53	33		2	16	13	23	26	15	2	13	19	21	26	13	331	
	CZE														37	13	17	17	3	16	1	15	32	4	31	34	68	6	2	296	
	NOR																								1	98	93		11	203	
	DEN																36	32	27	25				26	6		3	16	171		
	SWE																							9	17	31	53	47	4	161	
	FIN																		15				2	22	27	48	18	7	12	151	
	GBR																								26	31	22	9	55	143	
	UKR									65															8		6	13	23	17	132
	SRB																								24	12	9	22	26	93	
	CRO																1	12	13									23	37	86	
	GRE																								11	29		32	3	75	
	EST																								23	28			8	59	
	MON																												44	44	
	MDA																								6	12	8	5	11	42	
	SVK																											3	5	8	
NA	USA		2																2	15	66	17	18	98	141	253	336	346	764	2089	
	CAN														37	44	47	41		56	26	21	59	33	62	25	71	37	12	571	
	MEX																									1	18	31	23	73	
SA	BRA																								63	3				66	
	ARG									5																				5	



## DISCUSSION

The aim of this study was to investigate participation and performance trends in 12-hour ultra- runs regarding gender and nationality. We hypothesized (i) an increase in both the annual number of races and the annual number of runners, (ii) most races would be held in Europe and the largest participation would be among Europeans, (iii) Europeans would also show off the best performance, and (iv) the increase in participation among women and men would be of similar extent.

### *Participation in 12-hour runs increased over time*

A main finding was that the annual number of women and men showed a significant increase on all continents and for all origin continents, with the sole exception of races taking place in South America, where the number of runners of both genders showed no increase. Analogue to this, all countries that could welcome or provide at least 100 women and men each, showed a significant increase except of male participants in Switzerland.

Since the 12-hour run is a form of ultra-marathon, which is generally of increasing popularity (Hoffman, 2010; Hoffman & Wegelin, 2009; Knechtle et al., 2011a, 2012a; Lepers, 2008; Lepers et al., 2010; Skenderi et al., 2006), we hypothesized an increase in the annual number of races and participants. Our results showed that from the first 12-hour run in 1981, which was the sole in this year, the number of races increased to a maximum of 108 events in 2010. Over the 30 years study period 600 races took place all over the world, which of ~2%, 16% and ~82% accounted for the first, second and third decade, respectively. To that effect in 1981 there was only one participant compared to 3,311 in 2010. From 1981 to 2010 there have been 13,104 participants with viable information. The participants from 1981-1990, 1991-2000 and 2001-2010 accounted 80 (~1%), 1'768 (~13%) and 11,256 (~86%), respectively, to these runners. These numbers illustrate quite plainly the increasing popularity of 12-hour runs during the decades.

Our finding of an increasing participation is comparable to participation trends of other runs, e.g. 'New York City Marathon'. Lepers and Cattagni (2012) showed that participation of master runners in the 'New York City Marathon' increased during the 1980-2009 period and Jokl et al. (2004) found an increase of 119% over the period 1983-1999. Furthermore, concerning participation in distance running events such as marathon Burfoot (2007) found that since the early 1980s, it has advanced with hundreds of marathons worldwide and several events having more than 40'000 participants. Along with this trend in marathons the participation in 161-km runs (Hoffman & Wegelin, 2009) and in ultra-triathlons (Knechtle et al., 2011a; Knechtle et al., 2011b) showed a progressive increase in the number of starters after 1977 to 1986 and from 1985 to 2009, respectively. Among these studies, all of which found an increase to a similar extent, the finding of a stable entry in the number of total starters since 1990s (Hoffman & Wegelin, 2009; Lepers, 2008) breaks out of column. This seems apparently like a contradiction from the abovementioned trend but it's explained rather by a limitation in the number of entries than a lack of interest in participating in these events (Knechtle et al., 2010), what might be the explanation for the absence of a significant increase for men in 12-hour runs in Switzerland, too. Additionally, in Switzerland there was a high initial number of participants, in consequence the validity of its development is restricted. Unlike Switzerland, the reason for the absence of a significant increase in South America, given that the initial participation was low, must be of different cast. We assume that financial and social factors influence the organization and participation and therefore cause the moderate increase in 12-hour runs in South America.

For the investigation of the correlation between demographic characteristics and the increase in participation, we compared the development of the numbers of participants, population and income per person of countries, which provided and in which at least 100 women and men each participated. We found that the growth of the population was not in the least comparable to the growth of participation in 12-hour runs (see Table 1), e.g. Hungary, where the population even decreased while the participation increased. However, there might be a correlation to the income per person, which increased at least by a factor of 2, which was the case in South Africa. The higher income could provide access to a certain lifestyle, which implies more attention to personal needs e.g. avocations. For example, studies about motivation in masters' sport (Hodge et al., 2008; Ruiz-Juan & Zarauz, 2012) found that it was predominantly intrinsic. We must assume that there are several aspects, amongst others income per person and cultural background influencing participation in 12-hour runs.

#### *Europeans represented the majority of the participants*

Most of the 12-hour races were organized in Europe; accordingly it featured the highest annual number of participants and also represented the most frequent origin of participants. Our findings are underpinned on the one hand by a study about ultra-triathlons (Lepers et al., 2011), showing that European athletes represented the majority of participants in Double, Triple and Deca Iron ultra-triathlons, and on the other hand by a study about Double Iron ultra-triathlons (Sigg et al., 2012), which, across the years, gained more popularity in Europe and in European athletes compared to other continents. In this context Europe was followed by North America, what is comprehensible considering the fact that ultra-endurance sport events are very popular in the USA, e.g. marathons since 1976-present (Burfoot, 2007) and 161-km ultra-marathons (Holman & Wegelin, 2009), which date back to 1977.

As already mentioned, we must assume that participation in an ultra-marathon correlates to social and financial aspects. With this in mind the relatively affluent Europe and North America (<http://data.worldbank.org>) with their individualistic mindset are predestinated for high participation rates. Similar conclusions were drawn in connection with Double Iron ultra-triathlons (Sigg et al., 2012), in particular, that the rising number of participants especially from Europe and the USA might be due to the good financial situation and socioeconomic status of these continents.

To find out more about the origin of participants, the study was conducted on national level, too. Countries, in which at least 100 women and men each participated, were in descending order the USA, France, Germany, Russia, Austria, Switzerland, Canada, Australia, Hungary and Republic of South Africa. Analogue, the countries that provided at least 100 women and men each, were in descending order the USA, Germany, France, Russia, Austria, Canada, Hungary, Republic of South Africa and Japan. The countries, which stand out in both categories, were the USA, France and Germany. Since the 12-hour run was initiated and primarily held in Germany, it's self-evident that it plays a leadership role with influence on the neighboring countries, particularly Switzerland, France and Austria, which have similar socioeconomic background. In addition to the benefiting socioeconomic aspect for Central Europe there is at least one other, e.g. climate (Cheuvront & Haymes, 2001; Trapasso & Cooper, 1989), as it is described in the study of Sigg et al. (2012) countries in Central Europe showed moderate temperatures and a more equal number of sunlight hours across the seasons, so Central Europe may be the leading region for ideal training conditions.

Focusing on participation on national level, the USA represented the country with the most runners. Also, the USA provided the most runners, who participated in races outside their native country. This is explainable on the one hand by the relative high population of the USA and on the other hand, as above

mentioned, by the fact that ultra-endurance sport events are very popular in the USA (Burfoot, 2007; Holman & Wegelin, 2009). Therefore it's not surprising that the 12-hour run, which is also ranked among ultra-marathon events, is gaining popularity.

#### *Europeans dominated in 12-hour runs*

Regarding continent of origin of runners competing in 12-hour runs, Europeans achieved the longest running distances. Asia was in the second position, followed by North America. To define the ranking more precisely we referred the running distance also to country of origin. The female ranking was led by Japan, followed by Germany and Russia. The top three male countries were the same but the sequence was different, i.e. Russia, Germany and Japan.

Present literature about performance in endurance runs in dependency of geographical origin, for example Larsen (2003), Scott et al. (2003) and Lucia et al. (2006), devoted similar results. These studies showed that distance running in general was dominated by East African runners, more precisely from Kenya (Larsen, 2003), Ethiopia (Scott et al., 2003) and Eritrea (Lucia et al., 2006). Larsen (2003) examined performances in middle- and long-distance running for men in the major distances from 800 m to marathon distance (i.e. 42,195 m), Scott et al. (2003) involved runners specializing in 5,000 to 10,000 m distances, marathon runners, and a third group, comprised of track and field runners, track runners being runners up to 1,500 m. The sample of Lucia et al. (2006) comprised cross-country race (5,000 to 10,000 m distances) specialists. The deduction of the results of these studies on ours is not reasonable, because on the one hand the above mentioned three ethnicities were not represented in 12-hour runs from 1981 to 2010 and on the other hand there is the fact that the subjects of these studies were runners, who participated in races only up to marathon distance. The performances in 12-hour runs from 1981 to 2010 were in the range of 9,000 m to 161,417 m, whereof the median was 90,818 m.

Therefore and by way of comparison we consulted studies about Double Iron ultra-triathlons (Rüst et al. 2012; Sigg et al., 2012) and Triple Iron ultra-triathlons (Jeffery, 2012), showing a dominance of European participants. Even though triathlon is another kind of sport event than the 12-hour run, the comparison regarding performance is reasonable since it was found that the running segment in elite Olympic triathlon performances is the most decisive (Cejuela et al., 2012). Accessorily, we used the 100 km all-time list (<http://iaaf.org>) as reference for our hypothesis. The male list consists of 40 runners, Russia is the most represented country with 15 runners, followed by Japan with seven, France and Italy each with three runners. There were 28 runners in the female 100 km all-time list, whereof nine are Russian, eight are Japanese and in third position there are three countries, namely Italy, Great Britain and the USA, all of them represented by two runners. Summarizing the 100 km all-time list of both genders, it can be stated that European countries, most notably Russia, as well as one Asian country, namely Japan, stand out. Concerning performance regarding to nationality the above mentioned studies (Jeffery, 2012; Rüst et al. 2012; Sigg et al., 2012) and the 100 km all-time list (<http://iaaf.org>) correspond approximately, so the deduction can be drawn that Europeans dominated, which is in accordance with our finding.

The difference of the performance in 12-hour ultra-marathons regarding country of origin, in the manner of the explanation of the study of Sigg et al. (2012), might be due to physical characteristics (Hoffman, 2008), climate (Cheuvront & Haymes, 2001; Trapasso & Cooper, 1989), equipment (O'Connor & Vozenilek, 2011), and probably the socioeconomic status and financial status of a nation (<http://epp.eurostat.ec.europa.eu>). Naturally the training and preparation are important but more important is to do it properly as it was reported for Long distance triathlon (Laursen, 2011), some of these race strategies include appropriate training, pacing, nutrition and acclimating to the heat. Further aspects, e.g. percent body fat and duration

per training unit (Knechtle et al., 2012b), influencing the performance of an ultra-marathoner have to be taken into consideration. Jeffery's explanation amongst others was that most of Triple Iron ultra-triathlons and Double Iron ultra-triathlon were held in Europe where the popularity in these ultra-endurance events is greater (Lepers et al., 2011).

#### *Travelling due to economic reasons or just part of a certain lifestyle*

South American runners represented the largest number travelling to another continent to participate in a 12-hour run. To demonstrate the proportions, in races taking place in South America overall 71 runners participated, in comparison to 98 South Americans, who travelled to another continent to participate in a 12-hour race. So the number of South American runners, who started in races on their own continent, was smaller than the number of those, who travelled to another continent to participate in a race. This matter of fact could trace back to a financial incentive, e.g. as it is a motivation of national (39%) and international Kenyan (34%) runners, who declared economic reasons (Onywera et al., 2006).

Europe, North America and Asia were abundantly represented by their runners in races on other continents. Reasons for the fond of travelling of European, North American and Asian runners might be due to a certain lifestyle and advantaging financial condition (<http://epp.eurostat.ec.europa.eu>). Australian runners showed a moderate travelling manner, which might be related to the geographical location of their continent and therefore caused prolonged travelling, what might be a disincentive and a physiological stressor, too (Pipe, 2011).

#### *Same growth rate among women and men*

A further important finding was that the participation growth rate among women was nearly the same as among men, so the proportion of female and male participants showed no distinct trend. Due to studies about Double Iron ultra-triathlons (Rüst et al. 2012; Sigg et al., 2012) and Triple Iron ultra-triathlons (Jeffery, 2012), which found that the number of women slightly increased or remained stable, respectively, we hypothesized a stable participation percentage of women and men.

In 161-km ultra-marathons in America women typically have accounted for about 20% of participants in recent years (Hoffman et al., 2010; Hoffman & Wegelin, 2009) as was approximately the case in this analysis, concretely the percentage over the 30 years period for 12-hour runs was ~21%. Divided in the periods 1981-1990, 1991-2000 and 2001-2010 the corresponding percentages of female participants accounted ~21% (17 out of 80), ~16% (289 out of 1,768) and ~22% (2,464 out of 11,379), respectively. Thus there hasn't really occurred an increase in the percentage of female participants. Nevertheless the number of women increased. In contrast to our finding Hoffman & Wegelin (2009) showed a growth in participation among women from 10-12% in the late 1980s to 20-22%, where it has remained since 2001. This trend was confirmed by the finding of an increased participation of women from virtually none in the late 1970s to nearly 20% since 2004 (Hoffman et al., 2010). Knechtle et al. (2010) and Lepers (2008) found an increase in participation among women, too, from 0% in 1985 to 10% in 2009 and from 6% in 1981 to 27% in 2007, respectively. The absence of an increase of the female percentage in 12-hour runs might be due to the high initial participation, compared to the range of virtually none in 161-km ultra-marathons (Hoffman, 2010) and in ultra-triathlons (Knechtle et al., 2010) to the slight percentage of 10–12% in the 'Western States 100-Mile Endurance Run' (Hoffman & Wegelin, 2009), respectively. The difference between 12-hour runs and other ultra-marathons in the initial participation of women might be due to different initiating time. While ultra-endurance events in the USA date back to the 1800s (Brannen & Milroy, 2004; Hoffman & Wegelin, 2009; Milroy, 2004; Noakes, 2003), the first 12-hour run was held in 1981, so the ultra-marathon sports community had time to establish and gain popularity. In contrast to that the Double

Iron ultra-triathlon (Knechtle et al., 2011a) or the Triple Iron ultra-triathlon (Jeffery et al., 2012; Knechtle et al., 2011a) were initiated in a similar time as the 12-hour run, namely in 1985 and 1988, respectively. The difference of the female participation in the above mentioned races might be due to another kind of physical stress and different initiation time and therefore establishing time of the ultra-marathons.

Summing up the participation among women, Hoffman and Wegelin (2009) reported 20-22% since 2001 in the 'Western States 100-Mile Endurance Run', and in the USA in 2007 40% among all marathons and 50% among all road races, Lepers reported (2008) 27% in 2007 in the 'Ironman Hawaii', Hoffman (2010) reported 20% since 2004 in 161-km ultra-marathons in North America and Knechtle et al. (2010) ~10% since 2000 in the Double Ironman triathlon. Broadly speaking the number of female participants increased in endurance sport events, but is still distinctly lower than the number of male participants, while the percentages vary. In comparison to the mentioned numbers women in the 12-hour runs accounted for 22% over the period 2001-2010 and therefore integrate well in this arrangement of ultra endurance events. To visualize the increase here are some more figures, in 1981 there was only one participant, which was a female, in 2010 there were 3084, of whom 733 were women (~24%). The participation percentages during the last years regarding gender match most closely to those in 161-km ultra-marathons, what might be due to the similar physical stress level, since both are ultra-marathon events and consist only of one discipline, that is to say running.

#### *Strength, limitations and implications for further studies*

A strength is the large data set. However, some smaller races might not have been considered to be included in the records. In the present study we used information according nationality and gender. In addition to this the age and name of the runners should also be implicated to find the age group with the highest participation rate and the participation rate of each individual. Furthermore, given that the present study focused on performance in dependency only of geographical origin, prospective studies should investigate performance trends dependent on age and in this context also aspects which have an influence on performance, like training (Jeukendrup & Martin, 2001), anthropometry (Knechtle et al., 2011b), nutrition (Hulton et al., 2010), experience (Knechtle & Kohler, 2009; Knechtle et al., 2010; Knechtle et al., 2011b), and weather (Ely et al. 2007; Parise & Hoffman, 2011; Vihma, 2010) should be considered.

## CONCLUSIONS

To summarize, participation in 12-hour runs increased between 1981 and 2010. Europe was the continent with the most participants as well as the most frequent origin continent of participants. Also, European runners dominated in 12-hour runs. The USA, France and Germany were the countries with the most participants and whereof most participants originated. Participation among women and men increased similarly, so the proportion showed no distinct trend. Future studies need to consider more aspects concerning performance and relating to this differences between women and men.

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